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AMSAT's Newsletter for the Amateur Space Program.

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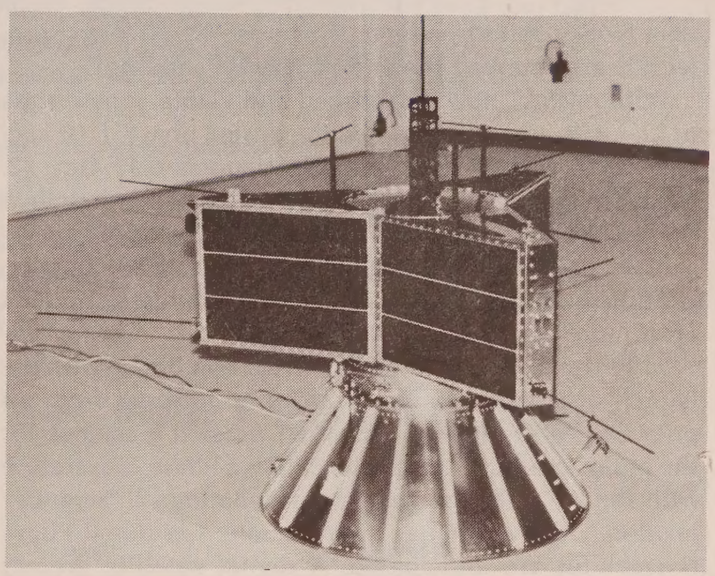
Special Edition Introduces AMSAT OSCAR 10

Last month amateur radio reached new heights in several senses. AMSAT OSCAR 10, the most advanced amateur radio project ever, was launched into orbit. Not only is AMSAT OSCAR 10 (AO-10) the most advanced satellite ever built by amateurs, it is in a much higher orbit than all prior OSCARs (Orbiting Satellites Carrying Amateur Radio). The realization of these two key facts (high orbit and high achievement) leads one inevitably to recognize the vast potential embodied in AO-10. And basically that's what has all the amateur radio world abuzz.

Within days (August 6), AO-10 itself will be abuzz with the first QSOs the general populace will enjoy. Thousands are expected to join in the first day activities, both veterans of prior OSCARs and satellite newcomers alike. Both groups will share the new AO-10 experience and while becoming familiar with the novelty of super vhf/uhf DX, they will be bringing the entire amateur radio community smack into the world of reliable, predictable inter-continental DX. Many thousands of others will soon follow as word of the success and enjoyment obtained by the first group reaches others.

This *ASR* Special Edition is especially designed to introduce the satellite newcomer to the basics needed to get started with AO-10 and concurrently to refresh the subject for veterans. Both groups should recognize at the outset that as with any new subject, one of the most important aspects of getting started and staying current is access to relevant information. Providing that information is the fundamental purpose of this Special Edition and of *ASR* in general.

Within these pages are contained the basic information one needs to get started and to understand the essentials of the subject. An exhaustive discussion would take volumes, of course. So the reader should fully expect to begin (or continue) exploring the subject of OSCARs in the available literature. Use this *ASR* as a start point, or, in space jargon, a vector, to point yourself in the right direction. You will find a notable body of work written over the last two decades on OSCAR. You will likely also find your enjoyment of OSCAR is deepened and broadened with a fuller understanding of the subject.



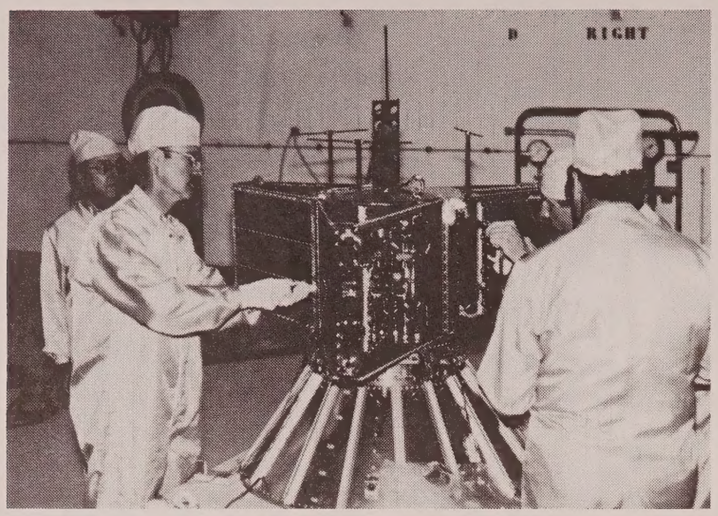
The completed satellite with test cables attached.

So begin (or continue) your investigation of the fascinating, enjoyable field of OSCARs with the *ASR* Special Edition and use it as a guide to more information you'll want and need to maximize your enjoyment of AO-10!

AMSAT OSCAR 10 Is First Of Phase III Birds

The launch of AO-10 last 16 June marked the transition to a new generation of OSCARs, Phase III. What is Phase III? It is a new breed of high-orbiting, long-life satellites that is just now emerging after years in the planning. Here's the background.

The first OSCAR was launched nearly 22 years ago on 12 Dec. 61. OSCAR 1 and the follow-on OSCARs 2, 3 and 4 were short-lived and, except for OSCAR 4, low-orbiters. All four were built by Project OSCAR of California. OSCAR 5 too was short-lived in a low-polar orbit but it was built by students at the University of Australia. AMSAT was formed in the Washington, D.C. area about this time (1969) and helped arrange the launch of OSCAR 5



Final assembly. (L-R) DJ4ZC, W4PUJ, W3GEY and DJ5KQ with back to camera.

on a NASA Delta N vehicle. This was AMSAT's first project. It also marked the end of Phase I satellites.

With AMSAT now established and viable, a new class of OSCARs, Phase II, entered the design phase. First success came with AMSAT OSCAR 6 launched 15 Oct. 72. Next came AMSAT OSCAR 7 on 15 Nov. 74 and then finally AMSAT OSCAR 8 on 5 Mar. 78. AO-6 lasted nearly 5 years, AO-7 endured nearly 7 years and AO-8, most recent of the Phase II birds apparently expired in June 83 after more than 5 years operation.

In 1981 a new sub-class of OSCARs was begun with the launch of UoSAT OSCAR 9. UO-9 is different from all prior OSCARs in that its PRIMARY mission is science for the radio amateur. It might be called a Phase IIS satellite with the "S" subclass designator denoting its "science" mission. UO-9 continues in operation. Additional Phase II satellites are anticipated. A digital satellite project called PACSAT is in the early design stages. It could be called a Phase IID satellite since it will be long-lived and Digital. The forthcoming JARL/JAMSAT satellite JAS-1 will likely be class Phase II/IID in that both classic Phase II and digital Phase II characteristics are incorporated. PACSAT could fly as early as 1985 while JAS-1 is targeting 84-85 as the likely launch era.

That brings us to Phase III. What characteristics distinguish Phase III satellites? The main distinction is of course the very high orbit. Next come the provisions for a long service life. A primary and spare battery have been included in the first Phase III birds. Battery problems have been the most likely failure cause for all prior OSCARs. With switchable battery capability, when the primary gets weak, the spare can be pulled from cold storage and placed in service. This could extend the life of AO-10 to beyond seven years; perhaps even a decade. AO-10 is the first Phase III satellite to be successfully launched. The first Phase III bird, Phase IIIA failed to attain orbit when the launcher failed in May, 1980. AO-10 was known as Phase IIIB prior to launch.

What does the future hold?

Phase IV satellites have been discussed and one project (ARNET) has been seriously proposed. Phase IV, like Phase III are long-lived. But Phase IV birds will be geosynchronous. The ultimate ham utility-repeater.

Other even more (literally) far-out schemes are in conceptualization stages. Phase V, we might call it, envisions not amateur satellites but amateur spacecraft leaving the vicinity of earth. The Solar Sail Project of the World Space Foundation is one that has been well publicized recently. (See *QST*, Feb. 83). Another project (unnamed) would send a probe to the asteroid belt between Mars and Jupiter. Yet another would launch an amateur space telescope which WOULD remain in earth orbit to do amateur science. Is this all there is for the future?

Not likely. With ham radio going into space in the person of Dr. Owen Garriott, W5LFL, on the Shuttle STS-9 mission, we find it easy to predict the day when manned space stations providing abode for dozens, perhaps hundreds of earthlings, are the ham shacks of the future. Imagine staying in touch with your ham hobby while circling earth at an earth-sun libration point!

Thus, while we are just now entering the Phase III era with the splendid achievement of AO-10, its sister craft Phase IIIC awaits a launch ticket, and Phase IV, V and beyond beckon enticingly to the imagination. Stick around. Amateur radio in space is only now moving from adolescence. The mature hobby will certainly spell wonders yet undreamt even as AO-10 was beyond imagining when OSCAR 1 beeped its Hi Hi only yesterday.

AO-10 Operations Guide Highlights

The following is a brief guide to AO-10 operations based on established plans and protocols. Mode B plans have been developed over the last five years. While no Mode L plans have been yet formalized, operating experience on Mode B will likely be used as a guide to Mode L plans.

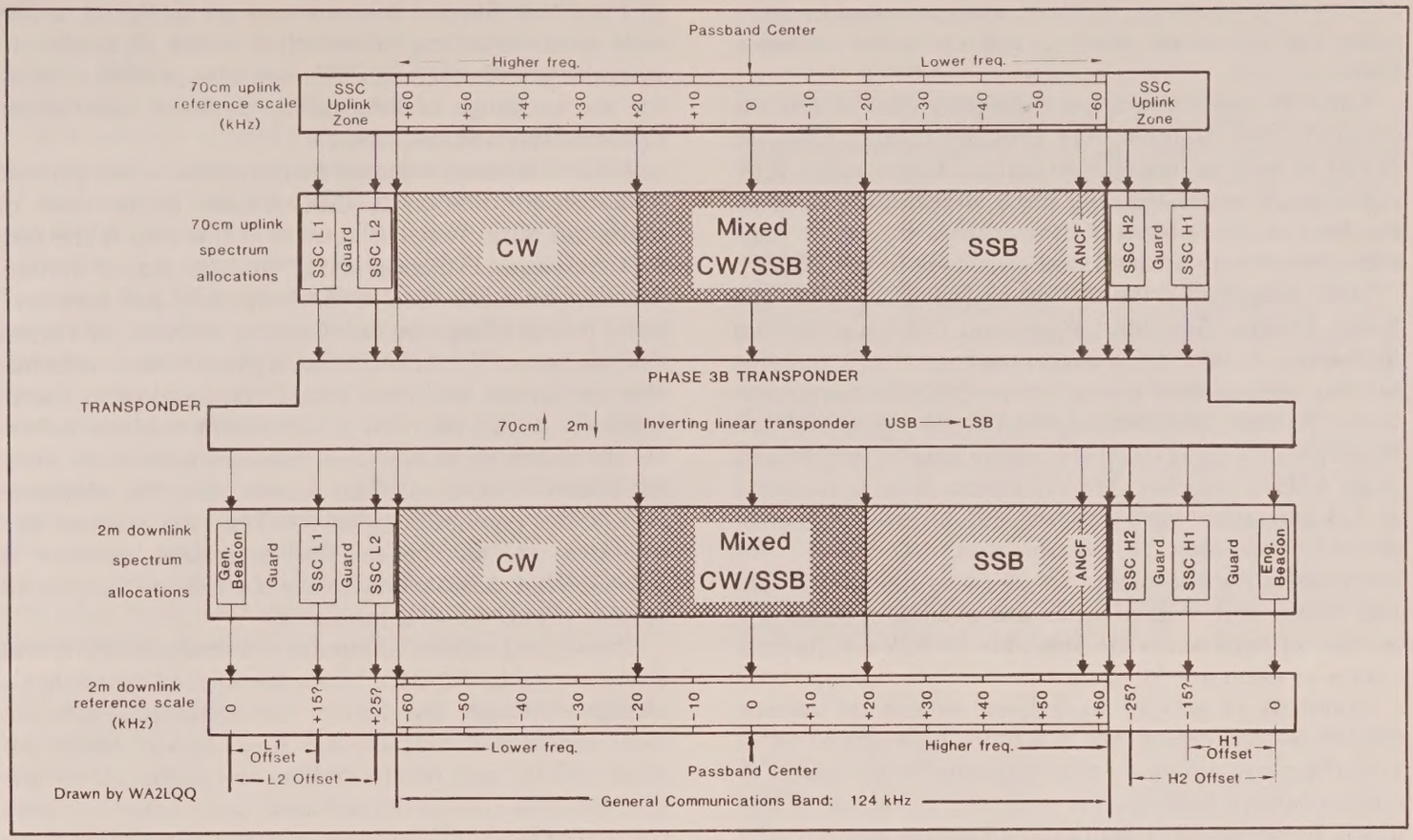
The bandplan schematic shown in this issue depicts the allocation of frequencies to various services. As may be seen, the upper one third of the downlink passband is for ssb, the lower one third for cw and the middle third is for mixed ssb and cw. The Special Service Channels (SSC) are reserved for scheduled use only as described in May 83 *QST* and *Orbit* #10. The AMSAT Calling and Net Frequency is set aside as well for specific activities.

The agreed standard for ssb emissions is LSB on the uplink which will result in USB on the downlink. Use no more than 750 to 1000 watts ERP on Mode B uplink ssb; less for cw. By all means use Right Hand circular polarization for uplink and downlink on Mode B and L. Uplink of 1000 to 2000 watts ERP on Mode L ssb will probably work very well while cw will again require less.

Bulletins, nets and other scheduled activities and services will begin almost immediately on the SSCs. Try to give them a wide berth and stick close to the center of the passband when possible.

Find your downlink using the accompanying table. Avoid the temptation to swish the band to find yourself as it only disrupts others and lessens the fun for all.

Be courteous of others at all times and observe the best operating habits and others will learn from you. Don't assume everyone speaks your language. Be prepared to help when requested.



OSCAR 10 Band Plan Chart

Your station should be well-prepared and put a good, clean signal out. Avoid excessive compression on ssb and insure your sidetone oscillator (or similar arrangement) is working properly. The propogation delays on AO-10 will make cw copying an interesting experience when listening to your own downlink.

Mode B will probably be on 6 or 7 days per week for general use. Mode L will begin operations perhaps this autumn with one day per week for experiments, etc. The specific day is yet to be decided. The proportion of Mode L versus Mode B time will increase as time goes on and traffic density on Mode B increases.

A guide to establishing a reasonably good ground station can be found in *QST*, April 83. Tracking data can be obtained regularly on the AMSAT Nets.

All are reminded that contests and other vigorous competitive events are strongly discouraged on AO-10 because of their disruptive effect on the productive use of AO-10.

In the event of a communications emergency, all or part of AO-10's resources may be committed to emergency service.

Info Sources Key To Success

For both the veteran and satellite newcomer alike, access to current, accurate information is vital. Without it, amateur satellite use becomes difficult and unreliable. AMSAT has long recognized this fundamental fact and has provided numerous channels by which authorative information may be obtained. The vital information is accessible through three basic channels: 1) Written word as with this *ASR*; 2) Spoken word as with the diverse AM-

Mode B Frequency Guide

Exclusive of Doppler shift.

Uplink		Downlink	
		145.987	Beacon, Engineering
435.025	Scheduled Use	145.972	SSC H1
435.035	Scheduled Use	145.965	SSC H2
435.038		145.962	Upper Limit
.040		.960	
.045		.955	
.050		.950	
.055		.945	
.060		.940	
.065		.935	
.070		.930	
.075		.925	
.080		.920	
.085		.915	
.090		.910	
.095		.905	
435.100	Center Band	145.900	
.105		.895	
.110		.890	
.115		.885	
.120		.880	
.125		.875	
.130		.870	
.135		.865	
.140		.860	
.145		.855	
.150		.850	
.155		.845	
.160		.840	
.162		145.838	Lower Limit
435.165	Scheduled Use	145.835	SSC L2
435.175	Scheduled Use	145.825	SSC L1
		145.810	Beacon, General

SAT on-the-air nets; 3) "Written" word provided by computer bulletin board services and computer software libraries.

AMSAT's publications are absolutely vital to success on AO-10. For example, *ASR* provides current news on AO-10 as well as forecasts of critical future plans. *ASR* publishes 26 issues annually and is widely recognized as the best in its field. *ASR* is available by direct mail subscription only as described elsewhere in this issue.

Orbit magazine is the official journal of AMSAT, The Radio Amateur Satellite Corporation. *Orbit* is published bi-monthly by AMSAT in magazine format and contains articles and columns by experts in OSCAR communications. It also provides organizational news and announcements. *Orbit* is a membership benefit one obtains as an AMSAT member. AMSAT membership is available at $24 annually (North America, $26 elsewhere) sent to AMSAT, P.O. Box 27, Washington, DC 20044. Life memberships are available for 25 times the annual rate and senior and student rates are available. A limited number of back issues are available for $2 each. Sample copies of *Orbit* are $1 each.

Hundreds of articles have been written on various OSCAR-related topics. These articles have appeared in virtually every amateur radio magazine in the world. A comprehensive bibliography is beyond the scope of this guide. However, ARRL maintains a Satellite Bibliography on articles which have appeared in *QST* over the years. This is being made available to ARRL members for an SASE with 3 units of postage. Write to ARRL, 225 Main Street, Newington, CT 06111; Attn: Satellite Coordinator.

The most complete bibliography of amateur radio articles is certainly "From Beverages Thru OSCAR — A Bibliography" by Rich Rosen, K2RR. This master work covers virtually every article of interest to amateurs including nearly all OSCAR-related articles from 292 different magazines including both amateur and commercial titles. The basic volume covers through 1978 while the first addendum covers 1979 through 1981. A subsequent addendum will cover 1982-1983. The entire biblography is available from Ham Radio's Bookstore, Greenville, NH 03048, for $39.95 for the basic volume with the first addendum.

AMSAT provides on-the-air information through dozens of nets spanning hf through uhf. Soon AMSAT nets will actually be held on AO-10. This should provide the highest level of information service ever to members and members-to-be. The key hf nets presently serving the amateur satellite community are the International AMSAT Nets held Sunday at 1800 UTC (21.280 MHz) and 1900 UTC (14.282 MHz). On 75 meters look for the AMSAT East Coast (U.S.) Net on Tuesdays at 9:00 PM Eastern time followed by the Mid-America Net at 9:00 PM Central and the West Coast Net at 8:00 PM Pacific all on 3850 kHz. AMSAT European 20 meter Net meets Saturdays at 1000 UTC on 14.280 MHz while the AMSAT UK Net meets on 3780 kHz on Sundays at 1015 and Mondays and Wednesdays at 1900 local time. A more complete listing is found in *ASR* 48/49, 27 Dec. 82.

The on-the-air nets have the major objective of providing very timely information for volatile events, that is, events which arise quickly and require rapid notification of members. Beyond this, the nets are designed to provide orbital tracking information, status of spacecraft operations and schedules. The nets also provide a forum for the exchange of information between experienced OSCAR-users and novitiates.

AMSAT recently initiated two activities which provide valuable information to OSCAR-users in the form of computer data. The first activity in this area is the AMSAT Software Exchange (ASE) Bulletin Board system. This service is provided AMSAT members and members-to-be free of charge by Bob Diersing, N5AHD, of Corpus Christi, Texas. The Bulletin Board (BB) contains information on current activities, orbital data and other useful features. It also provides a convenient mailbox system for the exchange of messages between individuals using the system. This is a dial-up system using the telephone lines and is compatible with Bell-Type 103 modems and operates at 300 baud. The telephone number is 512-852-9194. A basic how-to-use-it article on the ASE-BB appeared in *Orbit* #12, Jan/Feb 83.

The second related computer-oriented activity is also administered by N5AHD. This is the AMSAT Software Exchange. Through this facility computer programs for most personal computers can be obtained which will track AO-10 and most satellites including all of the OSCARs and Russian (RS) amateur radio satellites. Even the UoSAT OSCAR 9 amateur scientific satellite from the University of Surrey (England) can be tracked using the W3IWI tracking program available from the ASE. Complete instructions are contained in *Orbit* magazine #12 as above. Further information including price and delivery can be obtained from AMSAT Headquarters.

As posited above, success on the new OSCAR clearly depends on access by the potential user to current, accurate, authorative information. We have discussed the more formal channels by which this information may be accessed. Our discussion would be incomplete, however, if we failed to mention at least two other means of communicating OSCAR-related concepts, principles and procedures.

We highly recommend your attendance at AMSAT-sponsored satellite seminars and forums wherever they are held. Conventions are likely to have AMSAT-sponsored booths and even an OSCAR forum may be scheduled. Often experienced OSCAR-users can be found here who will gladly answer your questions. Occasionally you may meet an experienced OSCAR-user, AMSAT member who lives near to you. This is ideal since having an "Elmer" to help you along will often reduce the number and consequences of false starts beginners encounter. In the select fraternity of AMSAT members, many are eager to help newcomers to enjoy the excitement associated with OSCAR satellites. So attend conventions and seminars whenever you can either to learn and seek help or to teach and give help to others. More often than not, it's a combination of both even for the experienced, "Old Hands" at the conventions.

AMSAT will be sponsoring an elaborate Amateur Space Symposium in conjunction with its Annual Meeting for 1983. The Symposium will be held at the Applied Physics Laboratory of the Johns Hopkins University near Laurel, Maryland on 12 November, 1983. Because

of the preparations required for this meeting, it is strongly suggested that you reserve your position well in advance. Please contact AMSAT HQ at the address (telephone) listed above to reserve.

It is suitable to conclude this article on information sources with mention of an important work that will likely become the "bible" of OSCAR users throughout the world for years to come. The soon-to-be-published, "Satellite Experimenter's Handbook" by Dr. Martin Davidoff, K2UBC, will be THE single source needed by newcomers and veterans alike. Based on his prior, "Using Amateur Satellites in the Classroom," the new work is greatly expanded, copiously illustrated and completely up-to-date including valuable data on AO-10. The book goes to press soon and is expected to be generally available about October 1. ARRL is the publisher of the 300+ page sourcebook and AMSAT is among key distributors. You can help support AMSAT by obtaining your copy through AMSAT HQ. The price will be in the $10 class. Watch for announcements on the availability of this classic-to-be.

Information is vital to successful satellite use. AMSAT OSCAR 10 can be fun to use and an enjoyable experience...or it can be a frustrating disappointment. The difference could be as simple as your information source. Make AMSAT YOUR info source. Join today and subscribe to *ASR* too. And happy OSCAR-10ing!

AO-10 Spacecraft Hardware Most Advanced Ever

Viewed as a system, AMSAT OSCAR 10 is a dispersed complex of hardware, software, ground segment, space segment, user and controller. An overview of how these interrelated elements function is presented in a recent issue of *QST* (April, 83, pp 49) from which the following hardware description is excerpted. The associated figure provides a helpful reference.

In essence, the new OSCAR is simply a special type of repeater with a broad bandwidth to support many users simultaneously. It is situated to provide coverage of a large geographical area. In order to function the satellite requires a communication system (called a transponder *rather than a repeater), a power system and a control system. Let's see what makes up each of them.*

The Transponder

The transponder is made up of a receiver and a transmitter operating simultaneously on different frequencies. As with terrestrial repeaters, the receiver is connected to the transmitter. The big difference is that, for the terrestrial repeater, the signal from a single user is demodulated in the receiver, and then remodulates the transmitter. Thus, only a single 5-kHz fm signal can work through the repeater. On the other hand, satellite transponders are designed to have a moderately wide passband (in the order of several hundred kilohertz for OSCARs) so many stations can share the use of the "bird." The satellite transponders are really just frequency translators with linear power amplifiers.

Another difference between a typical fm repeater and an OSCAR transponder is that stations transmitting through the transponder are obliged to use linear modes such as ssb and cw rather than fm. The reason for this becomes obvious when one realizes electric power is limited to a few dozen watts for the entire spacecraft. It doesn't make much sense to use power-gobbling modes such as fm (F3) and a-m (A3A), since these modes consume power even when there is no modulation. Rather, ssb (A3J) and cw (A1) are the accepted modes since they dissipate power only when there is modulation or keying.

A final difference between a typical terrestrial repeater and an OSCAR transponder is that most terrestrial fm repeaters receive and transmit simultaneously on the same band. To do this, the repeaters must be provided with exraordinary filtering to prevent the strong local transmit signal from overloading the local receiver. Large duplexers and separate sites for transmit and receive antennas are often employed to overcome desensitization problems. Neither of these solutions is suitable on a spacecraft, of course, since weight and space are costly commodities on satellites. Most spacecraft are smaller than a typical automobile, so the transmit and receive antennas cannot be separated by more than a few feet. Therefore, the amateur satellites have adopted the same solution used on commercial satellites: receive and transmit simultaneously on widely separated frequencies (different bands). With the new OSCAR, two transponders will be available that offer two distinct uplink-to-downlink combinations. (They are listed elsewhere in this *ASR*).

As can be deduced, there will be a 150-kHz passband on Mode B and an 800-kHz passband on Mode L. The reason the downlinks are listed in reverse is because the passbands are inverted. That is, a signal entering the transponder receiver on the low edge of the uplink passband will be tranmsitted by the transponder transmitter on the high end of the downlink passband. Similarly, lower sideband on the uplink will be heard as upper sideband on the downlink. More on this in subsequent articles in this series.

Power System

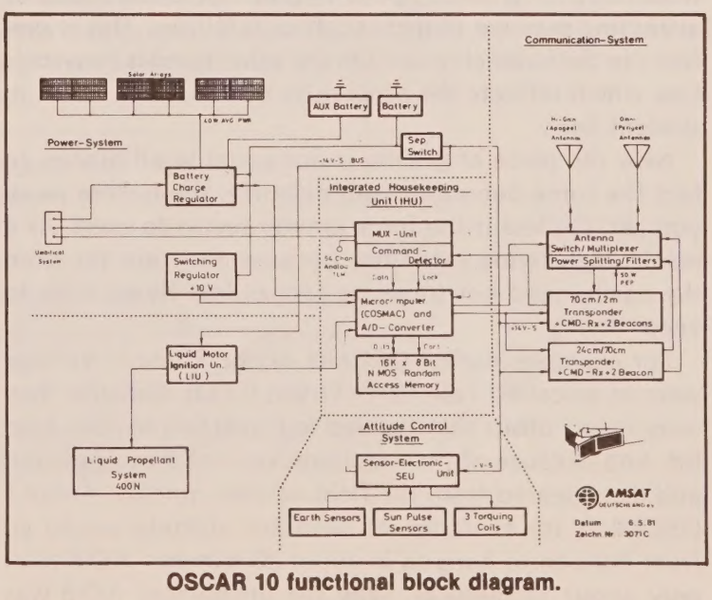
Next, let's see what's involved in the power system. As is well known, satellites are powered by solar energy, although they do carry small amounts of consumable stores (mostly pressurized gases or stored chemical energy, such as rocket fuel). Silicon solar cells are employed to convert solar radiant flux sunlight to electricity. The Phase IIIB solar panels will produce about 40 W when the satellite is first launched. The power generated is gradually reduced by the damaging effects of solar radiation and micrometeoroids. After five years, the power may be degraded by 20%.

The power from the solar cells is conditioned by a battery-charge regulator that ensures the longevity of the batteries. The nickel-cadmium batteries store the energy for use when the satellite travels through the earth's shadow. The spacecraft will carry two sets of batteries because the battery is the most likely component to fail in orbit. The primary battery is operated until telemetry indicates it has degenerated to a predetermined threshold, whereupon the alternate battery will be switched on-line.

Control System

The control system is probably the most complex of all. It consists of a number of major subsystems that we will describe briefly here, but which will be described in more detail in subsequent articles:

Integrated Housekeeping Unit (IHU): *The on-board computer that keeps the entire spacecraft running. It generates and formats telemetry,*



OSCAR 10 functional block diagram.

handles the transmission of bulletins on the beacons, computes and controls attitude, and does a host of other tasks.

Telecommand subsystem: *On board, this system receives command messages from ground-based telecommand stations, checks for accuracy and relays the commands to the IHU. The other half of this subsystem consists of the ground-based AMSAT telecommand team (primary stations are in the U.S., West Germany, Canada, New Zealand and South Africa, with supporting stations in Japan, England and Hungary).*

Attitude sensors: *Earth sensors and sun sensors "look" for the earth and sun, and provide inputs to the IHU, which uses the data to compute the proper attitude (orientation) of the spacecraft so the antennas are directed toward the earth.*

Attitude control subsystem: *Pulsed electromagnets that create a spacecraft-torque by interacting with the geomagnetic field when the spacecraft is near perigee. In essence, the spacecraft is the rotor of an electric motor and the earth's magnetic field is the stator. Magnet pulse timing is under IHU control.*

Kick motor subsystem: *Liquid-fueled, two-component propellant (nitrogen tetroxide and hydrazine) rocket engine that is fired to move the satellite from its initial orbit into the elliptical orbit that will be most beneficial to amateurs. The on-board fuel permits the motor to burn for a total of about five minutes shortly after launch and separation. This subsystem also contains the various valves and plumbing that control the propellants.*

Antenna subsystem:

2 meters — low-gain monopole or high-gain 6-element phased array ("ZL-special" beam).

70 cm — low-gain monopole or high-gain 3-element phased array.

24 cm — low-gain monopole or high-gain helix.

All antennas are right-hand circularly polarized (RHCP).

Getting To Know Elliptical Orbits

Even for those already familiar with Phase II OSCARs in their circular orbits, Phase III-type elliptical orbits can be a bit mystifying. A fundamental understanding of what's really going on, though, is important. Moreover, obtaining basic insight to orbital dynamics can be much easier than one might think once given a few building blocks on which to base more advanced concepts.

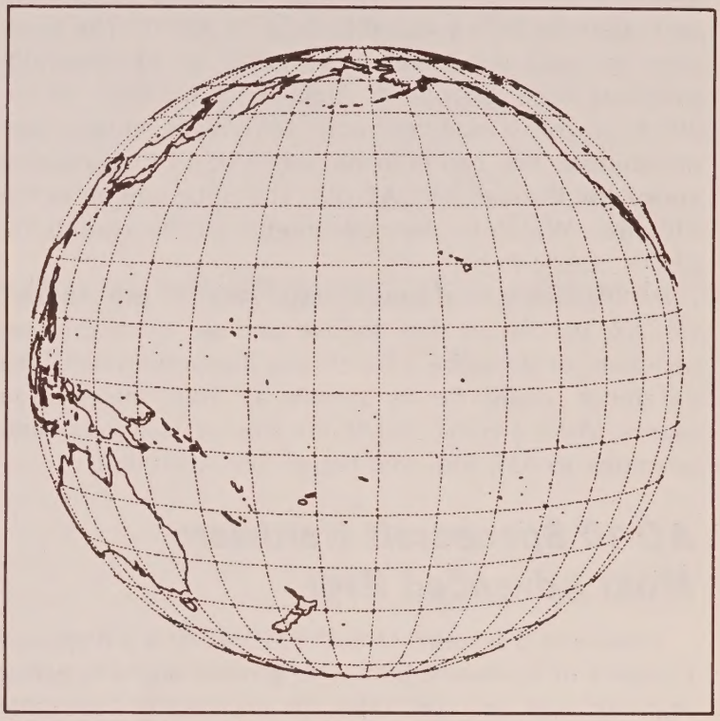
An object moving through space will continue indefinitely unchanged in its course unless affected by an outside force. This tenet, first postulated by Isaac Newton in similar terms, is the first of our building blocks of understanding. What it means is that there would be no such thing as an orbit without an outside force to affect the course of our object, a satellite. That outside force is, obviously, gravity.

An "orbit" is simply a series of points in space representing at a given instant the balance point between opposing forces. Gravity gives the appearance of attracting massive objects such as satellites. This is one force in the balancing act. On the other hand is Newton's Law which reflects the propensity of masses to travel in straight lines.

Now the force of gravity is not equal in all places. In fact the force decreases with distance; the further away you get, the less is the force gravity seems to exert. As a result, high flying satellites, because they are far from the earth, need not travel as fast as low flying ones to keep "flying."

For example, earlier OSCARs of the Phase II vintage were in so-called Low Earth Orbits (LEO). Because they were in low orbits they needed to travel fast to stay in orbit. And because of their rapid movement they appeared and disappeared from the field of view quickly. AMSAT OSCAR 7, for example, at 1450 km altitude would go from horizon to horizon in about 20 minutes. AO-8 took only about 18 minutes. Why the difference? AO-8 was lower; about 900 km and had to travel faster to stay in orbit. Thus it moved out of view more quickly despite being closer. The Shuttle at only 250 km can cover the horizon to horizon distance in only 8 minutes.

Thus, the higher the orbit, the slower is the satellite velocity. There is a special case that is of particular interest. If the altitude is 36,000 km, the velocity required is that which results in exactly one orbit per day. Moreover, if the orbital plane is in the equatorial plane, the satellite will appear to hover motionless. Thus is the so-called geo-synchronous satellite a balancing act too.



Earth as seen from AO-10 at 0807 UTC, 1 Aug. 83 over 5°N, 173°W exactly at apogee. Note coverage from Midwest U.S. to Japan, Australia, New Zealand. (By KA9Q)

Earth as seen from AO-10 apogee 19:46 UTC, 1 Aug. 83 over 5°N, 11°E. (By KA9Q)

From fortune!hpda!hplabs!sri-unix!cca!linus!allegra!eagle!karn Wed May 25 01:20:
Subject: Phase 3-B Notes
Newsgroups: net.ham-radio
The followins info is courtesy of AMSAT:

* The launch of Phase-III-B is now scheduled for June 16.
* Best present estimate for launch time is 12:00:32 UTC.
* The launch window is approximately one hour 45 minutes.
* It has been discovered (after potting) that the injection levels for both the 145.987 MHz Engineering Beacon (EB) and the 145.810 MHz General Beacon (GB) were set too high. The result is that with the Mode-B transponder off, the EB power output will be 6 watts (instead of 4 W) and the GB power output will be 2 watts (instead of 1 W).
* In order to save power in the early days of the bird's life it has been decided that the EB will be kept OFF most of the time and that the GB be used for both telemetry, ranging and informational bulletins.
* The message loaded into the Phase-III-B memory for ultimate transmission on the GB on CW and/or RTTY will read approximately as follows:

(notes)HI HI AMSAT OSCAR 10 AT XX:XX:XX UTC
1. ORBIT XXX MA XXX/256
2. UBAT XX.X VOLTS TBATT XX.X C IARRAY X.X A SA -/+ XX DG
SPIN XX RPM
SATELLITE STATUS:
FIRST MOTOR FIRING AND ORBIT CHANGE EXPECTED DURING
3. ORBIT 3
TRANSPONDER IS OFF UNTIL ABOUT ORBIT 10
LISTEN DAILY TO THIS BULLETIN FOR LATEST OPERATING NEWS
4. AT THE HOUR AND AT PLUS 30
AMSAT OSCAR 10 HI HI

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note-1 MA refers to the Mean Anomaly with 0 being at perisee
note-2 UBATT = battery voltage
TBATT = battery temp.in deg.C,
IARRAY = current in Amps of the Solar array,
SA = sun angle in plus or minus degrees
SPIN = space craft spin in Revs per minute
note-3 For reference sake, the orbit number increments at each perisee, with perisee zero occuring before 3rd stage shutdown and aposee zero occuring while the bird is over the Indian Ocean.

Tentatively, the planned schedule for usage of the General Beacon in the early orbits of AMSAT-OSCAR-10 is as follows:

Minutes past hour	EVENT
00 - 05	CW & RTTY BULLETIN
05 - 15	PSK used on General Beacon (Telemetry)
15 - 25	Possible Ranging otherwise PSK telemetry
25 - 30	PSK telem.
30 - 35	CW & RTTY BULLETIN
35 - 45	PSK used on General Beacon (Telemetry)
45 - 55	Possible Ranging otherwise PSK telemetry
55 - 60	PSK telem.

Subject: Amateur Allocations/emissions

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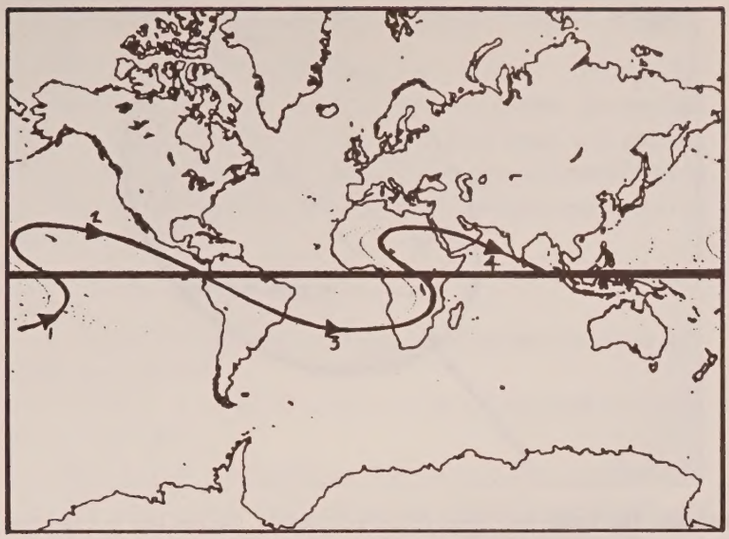
https://archive.org/details/amsat-60-61



The path through about 1½ orbits. Arrowhead shows progress of ground track. Prior orbit shown as dotted path where dots are spaced at 10 minute intervals. Notice how dot spacing changes evidencing changing orbital velocity. (By KA9Q)

One in which there are some very special balances involved.

We mentioned the phrase, "orbital plane." This means that a given orbit can be drawn on a flat sheet of paper; a plane. If you draw the orbit of AO-8 to scale on a sheet of paper and then hold the sheet of paper up to a globe so that the paper makes a 99 degree angle with the equator (sweeping counterclockwise from the equator) you'll begin to gain a feeling for the subject. The orbital planes change very gradually with time but the inclination which you modeled at 99 degrees changes even slower.

Most of the early OSCARs were in orbits that were highly circular. That is the difference between their high points (apogee) and low points (perigee) were small compared to the height. AO-7 was typical with apogee 1450 km and perigee 1435 km. Because of the nearly constant height above earth, tracking circular orbit satellites such as AO-7 was relatively easy. The ground track (path on the ground beneath the satellite) was conveniently a simple arc. The simplicity resulted in part from the fact that, as can be deduced from the remarks above, with constant altitude comes constant velocity.

Why is the ground track not a straight line since the orbit lies in a plane?

Simply because the earth is rotating while the satellite is making its way around. But what would happen if the altitude were to vary?

With an elliptical orbit such as that of AO-10, that's exactly what happens. The altitude is constantly varying from its apogee of 35,505 km to its perigee of 3,951 km. And with the changing altitude comes changing velocity in the orbital path. When at or near apogee AO-10 moves relatively slowly and appears to loiter in a leisurely manner. In sharp contrast when approaching perigee, AO-10 appears to accelerate rapidly and dive towards the earth on its way up to the next apogee.

The effect on the ground track is amazing and mysterious until one realizes that the on-orbit velocity is changing and that the earth is turning "under" the path of the satellite at a constant rate. The attached graphics by KA9Q offer a helpful visualization tool.

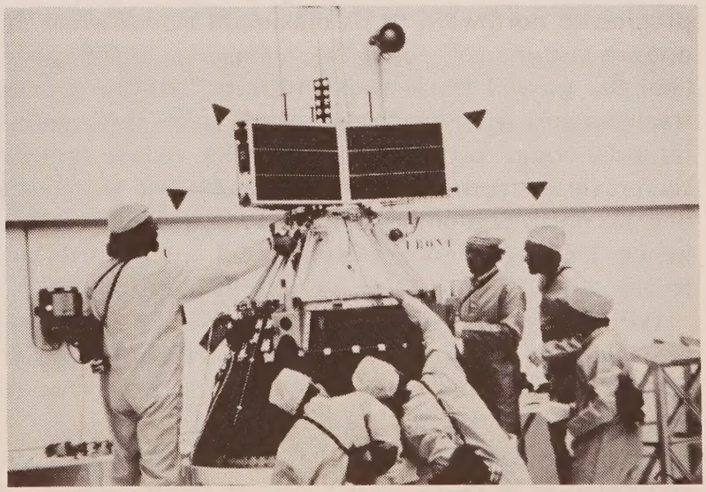
Beginning at the left of the map the satellite is over the western Pacific and heading up towards apogee. As it climbs in altitude its velocity in the easterly direction slows. Eventually the earth's east-to-west rotation overtakes the satellite's west-to-east motion and the net apparent movement of the ground track shifts from west-to-east to north and then to the northwest. The satellite reaches apogee (currently) when it is only 5 degrees north of the equator. That means that the "dots" should be bunched up in apogee area because the ground track moves slowest at apogee. One can see the effect with the dots over north central Africa where the dots, representing sub-satellite points ten minutes apart, clearly bunch up.

As the satellite begins its descent from apogee we see the direction of the ground track again switch from northwest to north, then almost due east as it quickly accelerates towards perigee. The dramatic difference can be understood when it is pointed out that the time interval between arrow heads 1 and 2 is about 8 hours while the interval between 2 and 3 is less than an hour. The next apogee occurs over central Africa again at 5 degrees north and the cycle repeats itself.

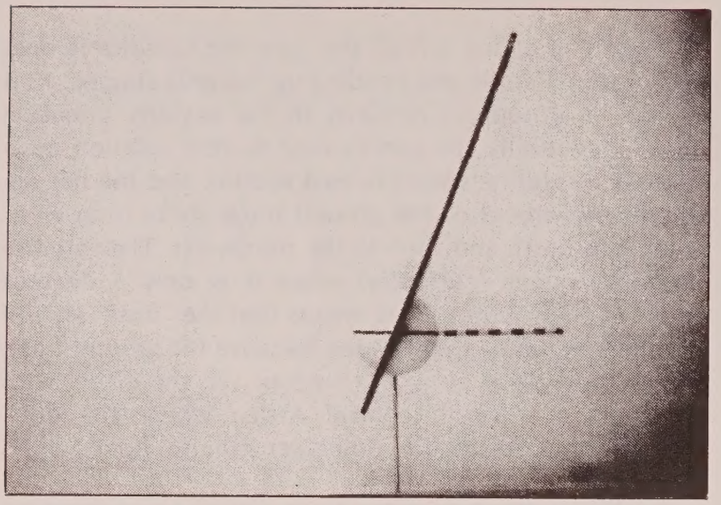
Some things to note about the orbit are these. Successive equator crossings occur about 175 degrees apart. Every second equator crossing occurs about 350 degrees of longitude apart giving the appearance of a 10 degree easterly progression of daily orbit trends.

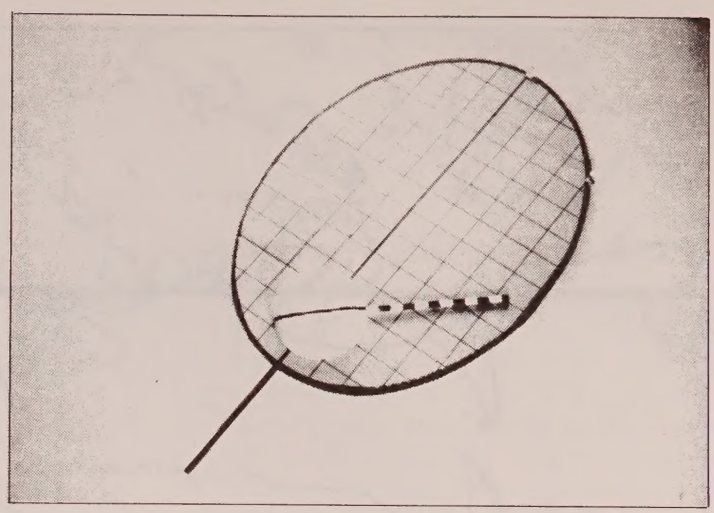
Now it becomes clearer why manual tracking devices such as the OSCARLOCATOR and Satellabe do not work for AO-10. They simply do not account for the difference in altitude (and the varying velocity) of elliptical orbit satellites. However, Kaz Deskur, K2ZRO, inventor of the famous Satellabe, has come up with a solution for Phase III satellites like AO-10. He calls it the Satellipse and it is a project you can build for your own use. The article describing K2ZRO's new Satellipse appears in the upcoming issue of *Orbit* magazine, #14, which is now in printing.

Thus the main differences between Phase II and Phase III orbits are attributable to changes in velocity of the satellite in its orbit which in turn results from its elliptical orbit. So the bewildering hairpin turns in the ground track are not so mysterious when these effects are taken into account.



Checking the fit.





A model of the earth and the Phase IIIB orbit is shown in the photos above. The scale has been adjusted slightly. On the left is seen the earth (white circle), with the equator marked (horizontal solid line). North is up. The striped marker lies in the plane of the equator. The long, dark oblique line is the orbital plane seen edge-on. The inclination of the orbit is the angle between the striped marker counterclockwise to the orbital plane (dark line). As configured here, that angle is about 60°. (The ascending node is on the near side of the model.) The photo on the right is of the same model from a different perspective. In fact the change has been 90°. Here the orbit can be seen to be an ellipse and the shape can be inferred from the grid. As can be seen, the grid presents not squares but diamond shapes since the top of the ellipse (apogee) is further away than the bottom (perigee) from the viewer. The satellite is assumed to move counterclockwise around the ellipse. The striped marker has now been moved to that point on the equator where the plane of the orbit intersects the plane of the equator (ascending node). A solid black marker is seen extending from the perigee point. Begining at the striped marker and rotating counterclockwise to the solid marker yields an angle called "argument of perigee." Here it is shown to be about 225°. The geometry of the model approximates the Phase IIIB orbit after kick motor burn.

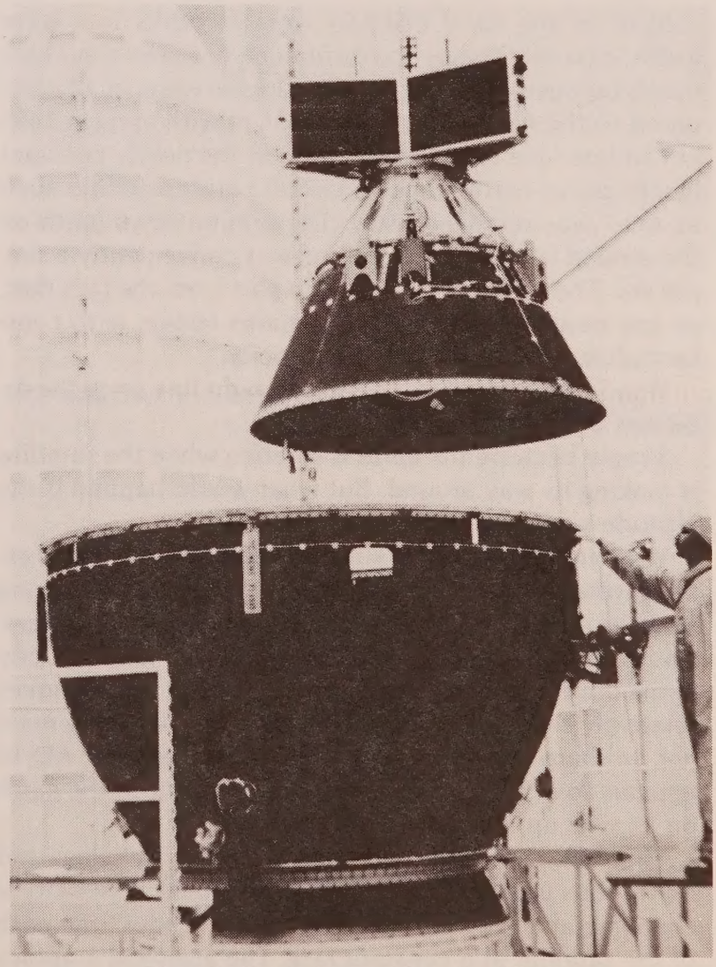
But there are a few other new terms that should be familiar. One of the most important is "Argument of Perigee." The accompanying photos show the argument of perigee that had been planned for AO-10 along with the planned inclination near 60 degrees. The caption explains what this important angle is.

Argument of perigee changes with time and thus the orbital plane will appear to precess in such a way that the latitude at which apogee occurs will change. The latitude at which apogee occurs is significant since it affects the duration of access times a given QTH will enjoy as well as the particular DX vista available to that QTH. The rate of change of argument of perigee and thus the rate of change of the apogee latitude depends on the inclination, eccentricity and semi-major axis of the orbit. In AO-10's orbit the rate of change of argument of perigee is 0.2710 degrees per day.

At this rate it will take about 3.64 years for the argument of perigee to complete one full 360 degree cycle and return to its present value of about 188 degrees. As mentioned above, apogee now occurs at 5 degrees North. In about 11 months the apogee latitude will have progressed northward to its maximum extent when the apogee latitude will equal the inclination, 25.8 degrees. (See the ground track map and note that the ground track travels as far north and south as 25.8 degrees of latitude, equal to the inclination.) The apogee latitude then reverses its trend and moves southward reaching 5 degrees north 22 months hence and 25.8 south 33 months hence. Then again apogee latitude will move northward to 5 degrees North roughly 44 months hence.

With a hoped-for life of at least seven years, it seems possible that two complete cycles of this progression can be realized and enjoyed by users in Northern and Southern Hemispheres alike.

There are a number of other terms that will be encountered in working with elliptical orbits. They may seem strange but each is readily understood when basic elements are set forth. Articles on Phase III orbits have appeared in *Orbit* magazines #6 and #11. A full treatment will appear in the forthcoming ARRL/K2UBC book, "Satellite Experimenter's Handbook." A detailed explanation of the Keplerian elements and their meaning can be found there.



The satellite is lowered into the SYLDA.

Tracking Programs Prove Their Merit

With the successful launch of AMSAT OSCAR 10, many of the tracking devices and programs developed by AMSAT members over the past few years are getting their first real "workout." Most have proven excellent in providing the key information for locating and tracking AO-10.

Tracking AO-10 in its orbit can be done in four basic ways:

1) "Tune" for maximum signal and refine antenna settings periodically

2) Employ a table of az-el values computed for your particular QTH

3) Employ an analog device similar to the Satellabe or OSCARLocator but with special features to properly account for the effects of the highly elliptical orbit

4) Employ a digital computer with suitable programming to compute az-el as well as SSP, Apogee, Perigee, Doppler, etc.

Each method has its merits and its deficiencies. Let's review them.

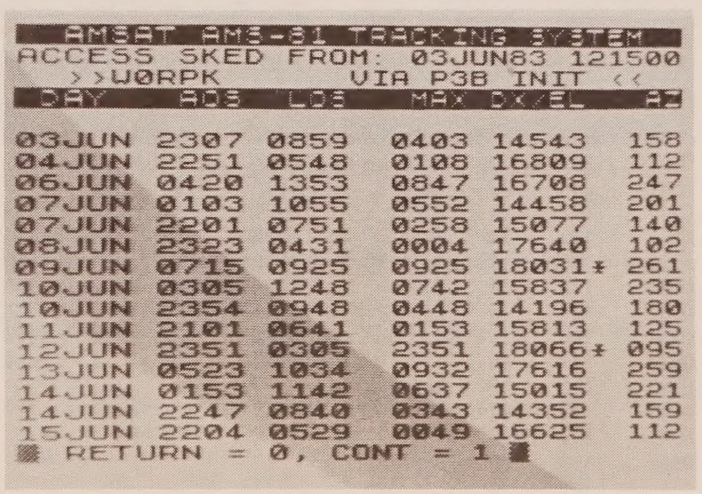
Method 1. Easiest. Involves no preparation or knowledge. Given a hint by a friend what general direction to look, you can peak up on AO-10 without too much difficulty. No "tools" or investment required. Scheduling is a problem. Without help from a friend you won't know when or where to look; you won't know when to expect loss of signal (LOS). Moreover, you won't be able to predict when DX areas you are especially interested in will be in view of AO-10.

Method 2. Next easiest. Who will generate the table for you? A friend with a computer could help. Products of this type will no doubt be offered for sale by entrepreneurs. The table will likely be quite long (large) if it gives accurate pointing directions. It will have to be customized for your QTH or one nearby, say within 100 miles (160 km) or so. You will require an input piece of information such as time and longitude of equator crossing or perigee point. You will need to keep careful track of this info or obtain regular, periodic updates for your table of pointing angles to work. As with method 1, you'll not know what DX areas will be within range simultaneously with your access. Prediction of special windows of opportunity will be very difficult.

Method 3. Several prototype trackers have been demonstrated. Those by K2ZRO and W2FGG have been reviewed in the past by *ASR* Editors. (A recent design by K2ZRO appears in *Orbit* #14 soon!) Provides excellent perception of position of satellite, motion, visibility contours, mutual visibility windows, pointing angles for antennas and in some cases range. A version by K2UBC in his forthcoming book is especially good at this. A major fault with this method is that the overlays must be changed regularly. The factor affecting the tenure (useful period) of a given overlay is the "argument of perigee" parameter. It changes with time and so the locator overlays must also be changed with time. The rate at which argument of perigee changes (and thus the relative frequency with which overlays must be changed) depends on the inclination of the orbit attained by AO-10. In a perfect Molniya orbit the inclination is a bit over 63 degrees and the argument of perigee stays fixed. At lesser or greater angles it changes. At the 26 degree inclination of AO-10 the overlays for the locators will likely need to be changed every 30 days or so depending on how large a pointing error is to be tolerated. (See also *Orbit* #8, Page 11. Mission Planning Phase III Orbit Alternative by W3IWI and WA2LQQ).

Method 4. This is by far the most versatile of tracking methods and, if you don't already have a computer you use for other things, the most expensive to get started. Advantages besides versatility include breadth of information available including pointing, range determination, Doppler computation, mutual window determination, long-term scheduling, precision AOS/LOS computation, etc. Also, hooking up automatic antenna pointing circuits can be accomplished given adequate access to the computer's I/O ports. As with all methods except the first you'll need an outside source of information. Here you'll need the most complex info too: The Keplerian element set (Brower elements) are required. These are available from AMSAT (in *ASR*) and NASA. Programs to run Phase III tracking programs are available from AMSAT for most popular personal computers in a broad variety of BASIC dialects. The program is also available in FORTRAN (late level). The AMSAT Software Exchange administered by N5AHD is addressable at P.O. Box 27, Washington, DC 20044 for your inquiries. A small charge is made for software. With highly elliptical orbits like that of AO-10, the orbit is stable for very long periods. Thus, frequent Keplerian updates will prove unnecessary in contrast to prior OSCARS. Avoid simple, homebrew programs as they likely will NOT work with AO-10. Many programs are now being advertised for OSCARs that WILL NOT TRACK AO-10! *Caveat emtor.*

One program which has enjoyed an especially broad success is the AMS-81 package developed for AMSAT by a team under WØRPK. It runs on the Timex/Sinclair 1000 (ZX-81) with 16K RAM package and is at present about the least expensive "Method 4" approach available. The TS-1000 was recently selling for as low as $30 and the 16K RAM for $40. The AMS-81 s/w on cassette costs $15. Thus, for less than the cost of a single 3-500Z, one can automate. In fact, many have found that at this level of cost, one can set up the TS-1000 as a dedicated microprocessor and station accessory doing nothing else but tracking or scheduling. The AMS-81 software is available by sending a check in the amount of $15.00 to



AMSAT to: AMS-81 Tracking System, c/o Bob McCaffrey, KØCY, 3913 29th St., Des Moines, IA 50310. (See CRT photo of display elsewhere in this issue.) An enhanced version with special hardware is being developed too. According to Project Leader KO5I, it will automatically point your antennas. Watch for announcements on this project in these pages.

As can be deduced, tracking AO-10 can be as simple or as complex as you care to make it. It can be likewise as expensive or inexpensive as you care to make it. With more complexity and expense comes versatility and capability. Choose the complexity and capability which suits you best. And enjoy AO-10 no matter how you choose to track it.

Mode B Operations Begin 6 August

As we go to press we have learned that the beginning of Mode B operations is planned for 1800 UTC on 6 August. AMSAT OSCAR 10 will be over Europe at the time and will rise in the western U.S. about five hours later. Hams in the Los Angeles/San Diego area will be the first on the mainland U.S. to hear and use AO-10 Mode B. AO-10 will rise on the East Coast at about 23:26 UTC. The tracking data below is for the first Mode-B-on pass on late 6 August, early 7 August. Seven locations around the country were selected as representative. Pick the one which is nearest to you and use it as a starting point. Then by estimating, you should be able to improve on the initial antenna pointing by adjusting the position of your beams for maximum signal.

6 Aug. New York

UTC	Az	El	Range
2326	218	00	19923
2348	214	09	22765
7 Aug.			
0021	212	17	26458
0114	215	25	31461
0240	226	30	36630
0346	236	31	38211
0451	247	29	37764
0557	255	28	35128
0735	264	29	26159
0837	259	39	16324
0855	248	46	12598
0908	231	51	10050
0914	216	53	8856
0918	201	53	8861
0922	187	50	7510
0925	175	46	7174
0928	165	41	6955
0931	156	34	6875
0934	148	27	6947
0938	142	19	7174
0941	136	11	7547
0944	132	03	8048
0945	126	00	8293

6 Aug. Chicago

UTC	Az	El	Range
2316	209	00	18280
2338	202	10	21015
7 Aug.			
0007	198	18	24543
0051	197	27	29099
0204	204	35	34453
0317	216	38	37169
0431	229	39	37380
0544	241	38	34982
0710	251	39	27540
0826	248	48	17606
0849	234	55	13290
0900	217	59	11047
0908	199	60	9710
0913	181	57	8753
0918	167	53	8154
0922	154	46	7708
0926	144	37	7467
0931	135	27	7473
0934	131	19	7626
0936	127	12	7895
0939	123	05	8274
0941	119	00	8574

6 Aug. Denver

UTC	Az	El	Range
2301	203	00	15526
2317	193	08	17564
2339	184	16	20563
7 Aug.			
0013	178	24	24793
0103	175	33	29790
0214	182	41	34486
0325	194	47	36664
0436	208	50	36489
0547	223	51	33881
0724	236	54	25738
0830	223	65	16087
0849	195	69	12681
0859	170	68	11022
0906	151	63	9947
0912	136	55	9043
0917	128	46	8562
0922	121	35	8289
0926	117	27	8252
0930	114	17	8382
0933	111	08	8682
0937	108	00	9051

6 Aug. Los Angeles

UTC	Az	El	Range
2248	204	00	12922
2257	194	06	14078
2307	186	11	15390
2321	177	16	17435
2342	169	22	20464
7 Aug.			
0021	160	30	25366
0118	157	38	30765
0216	161	46	34247
0335	173	55	36341
0454	191	61	35504
0613	210	64	31607
0752	220	72	21471
0832	179	78	15429
0847	139	75	12978
0857	121	67	11415
0904	112	58	10375
0909	108	51	9797
0914	104	42	9357
0919	102	31	9099
0923	100	23	9047
0927	099	15	9132
0930	098	06	9357
0933	097	00	9606

6 Aug. Miami

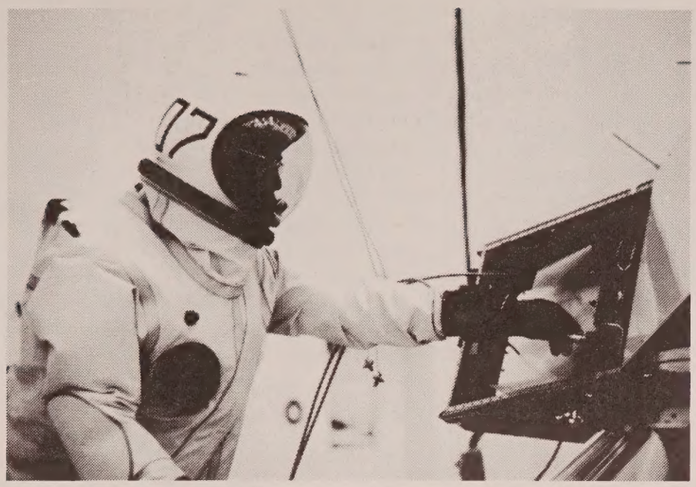
UTC	Az	El	Range
2303	225	0	15811
2316	220	10	17208
2329	217	17	18757
2349	214	26	21209
7 Aug.			
0019	212	34	24707
0110	216	42	29713
0230	229	46	35013
0335	232	44	37018
0439	253	40	37089
0544	263	36	35100
0714	273	34	28226
0832	278	44	16726
0849	276	52	13357
0901	273	60	10962
0909	264	70	9165
0915	244	77	8038
0919	197	81	7284
0922	160	78	6855
0926	135	67	6371
0929	127	59	6187
0931	123	49	6139
0934	120	39	6235
0937	118	29	6477
0940	116	19	6854
0943	115	11	7347
0945	114	03	7936
0946	113	00	8167

6 Aug. Dallas

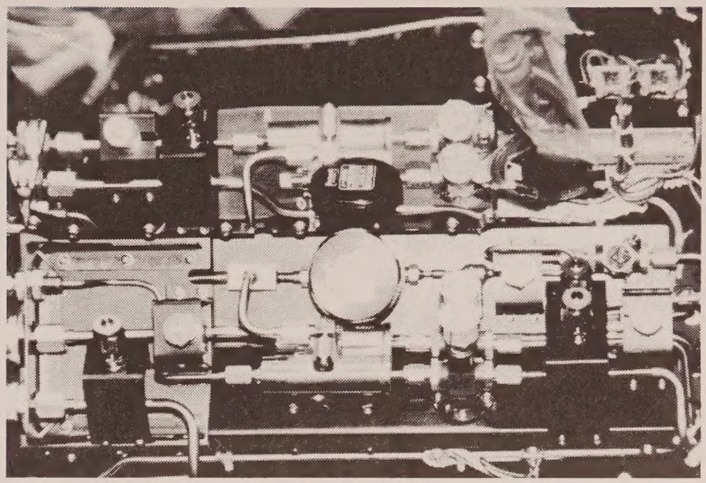
UTC	Az	El	Range
2258	214	00	14825
2312	205	09	16449
2329	197	18	18727
2324	191	27	21955
7 Aug.			
0032	187	35	26267
0130	190	43	31359
0300	205	50	35850
0404	219	51	36696
0508	233	51	35641
0611	245	49	32519
0821	256	59	17860
0845	245	68	13501
0901	203	77	10466
0907	168	75	9405
0913	141	68	8475
0917	130	61	7978
0921	123	52	7623
0925	118	41	7449
0928	115	33	7456
0931	113	24	7590
0934	111	16	7851
0937	110	07	8229
0940	108	00	8664

6 Aug. Seattle

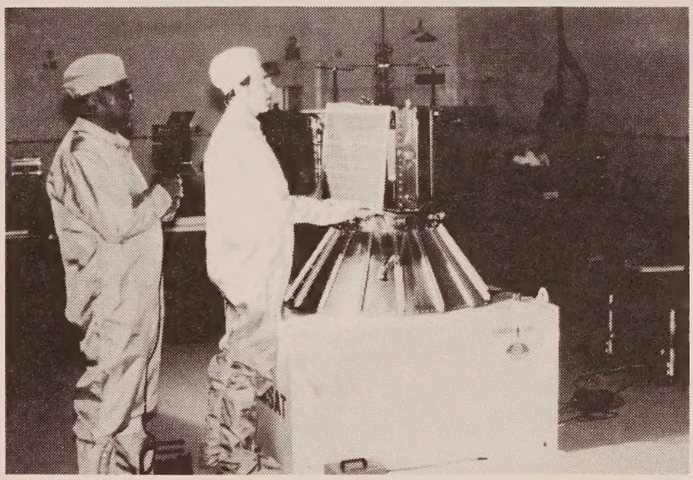
2315	176	00	17966
2335	167	06	20976
7 Aug.			
0010	160	13	25474
0105	156	22	30946
0159	158	29	34618
0317	166	38	37172
0434	177	45	36868
0552	189	50	33683
0813	183	60	18973
0835	166	59	15487
0848	150	56	13363
0857	139	51	12028
0906	128	42	10870
0912	120	33	10211
0918	114	24	9866
0922	110	16	9759
0927	106	07	9824
0930	103	00	10020



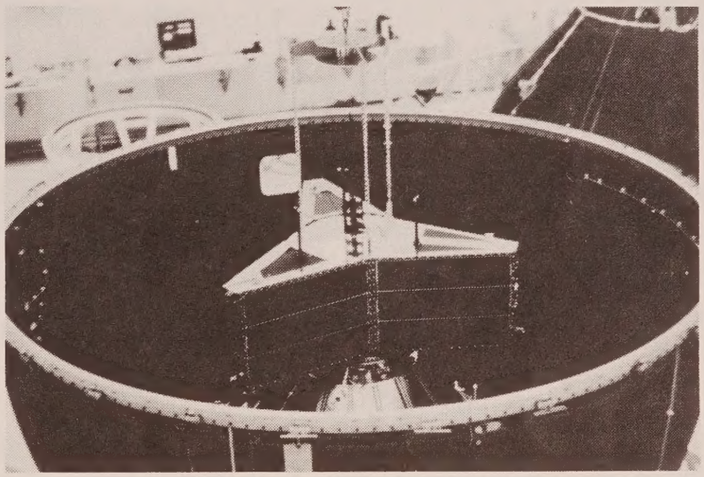
W4PUJ in protective suit fueling AO-10 at Kourou prior to launch.



Liquid Ignition Unit (LIU) built by W4PUJ.



Testing the solar panels are K. Mueller (left) and U. Mueller.



Lowering the completed satellite into the SYLDA canister bottom.

Orbit Predictions

By Phil Karn, KA9Q

Listed here and on the next page are current computer printouts for various amateur radio operating satellites.

```
rs-3:
Wed Jul 27 00:40:20 1983 UTC: Ascending node at 0.3 west
Nodal period: 118.51849 min
Longitude increment: 29.756458 deg w/orbit
Element set     72, epoch: Sun Jul 10 07:41:06 1983 UTC
rs-4:
Wed Jul 27 01:10:49 1983 UTC: Ascending node at 2.3 west
Nodal period: 119.39369 min
Longitude increment: 29.975360 deg w/orbit
Element set     128, epoch: Mon Jul 18 00:16:54 1983 UTC
rs-5:
Wed Jul 27 00:09:44 1983 UTC: Ascending node at 346.1 west
Nodal period: 119.55479 min
Longitude increment: 30.015796 deg w/orbit
Element set     101, epoch: Wed Jul  6 21:57:28 1983 UTC
rs-6:
Wed Jul 27 00:25:19 1983 UTC: Ascending node at 355.3 west
Nodal period: 118.71595 min
Longitude increment: 29.805854 deg w/orbit
Element set     59, epoch: Mon Jul 18 08:40:09 1983 UTC
rs-7:
Wed Jul 27 01:36:30 1983 UTC: Ascending node at 10.2 west
Nodal period: 119.19529 min
Longitude increment: 29.925790 deg w/orbit
Element set     114, epoch: Thu Jul  7 02:50:26 1983 UTC
rs-8:
Wed Jul 27 00:53:34 1983 UTC: Ascending noce at 355.9 west
Nodal period: 119.76381 min
Longitude increment: 30.068016 deg w/orbit
Element set     233, epoch: Mon Jul 11 09:37:58 1983 UTC
```

W3GEY prepares decal for third stage fairing.

```
oscar-8:
Wed Jul 27 00:51:28 1983 UTC: Ascending node at 98.2 west
Nodal period: 103.16693 min
Longitude increment: 25.794017 deg w/orbit
Element set     777, epoch: Sun Jul 17 10:27:06 1983 UTC

oscar-9:
Wed Jul 27 00:55:14 1983 UTC: Ascending node at 143.6 west
Nodal period: 94.63742 min
Longitude increment: 23.657987 deg w/orbit
Element set     489, epoch: Mon Jul 18 08:42:49 1983 UTC
```

```
Satellite: oscar-8
Catalog number: 10703
Epoch time:      83198.43548887
   Sun Jul 17 10:27:06 1983 UTC
Element set:          777
Inclination:       98.7569 deg
RA of node:       209.6771 deg
Eccentricity:     0.0006060
Arg of perigee:    242.1463 deg
Mean anomaly:      117.9073 deg
Mean motion:   13.96566868 rev/day
Decay rate:      -3.9e-07 rev/day^2
Epoch rev:           27346
Semi major axis:  7281.037 km
Anom period:    103.109993 min
Apogee:            923.634 km
Perigee:           914.809 km
Translate freq:   581.0974 mhz
Invert:                  1
Beacon:           435.0965 mhz
```

```
Satellite: rs-3
Catalog number: 12997
Epoch time:      83191.32021167
   Sun Jul 10 07:41:06 1983 UTC
Element set:           72
Inclination:       82.9597 deg
RA of node:       323.1865 deg
Eccentricity:     0.0058523
Arg of perigee:    346.4632 deg
Mean anomaly:       13.4858 deg
Mean motion:   12.15577793 rev/day
Decay rate:          3e-08 rev/day^2
Epoch rev:            6925
Semi major axis:  7987.371 km
Anom period:    118.462184 min
Apogee:           1657.125 km
Perigee:          1563.636 km
```

```
Satellite: rs-6
Catalog number: 13002
Epoch time:      83199.36121997
   Mon Jul 18 08:40:09 1983 UTC
Element set:           59
Inclination:       82.9601 deg
RA of node:       319.9833 deg
Eccentricity:     0.0049759
Arg of perigee:    345.8340 deg
Mean anomaly:       14.1327 deg
Mean motion:   12.13554263 rev/day
Decay rate:          4e-08 rev/day^2
Epoch rev:            7010
Semi major axis:  7996.254 km
Anom period:    118.659713 min
Apogee:           1659.159 km
Perigee:          1579.582 km
```

```
Satellite: oscar-9
Catalog number: 12888
Epoch time:      83199.36307327
   Mon Jul 18 08:42:50 1983 UTC
Element set:          489
Inclination:       97.5463 deg
RA of node:       165.6240 deg
Eccentricity:     0.0002682
Arg of perigee:    165.1355 deg
Mean anomaly:      194.9991 deg
Mean motion:   15.22502017 rev/day
Decay rate:      3.859e-05 rev/day^2
Epoch rev:            9854
Semi major axis:  6873.402 km
Anom period:     94.581155 min
Apogee:            498.484 km
Perigee:           494.797 km
Beacon:           145.8250 mhz
```

```
Satellite: rs-4
Catalog number: 13000
Epoch time:      83199.01173905
   Mon Jul 18 00:16:54 1983 UTC
Element set:          128
Inclination:       82.9672 deg
RA of node:       324.4807 deg
Eccentricity:     0.0016872
Arg of perigee:     38.7798 deg
Mean anomaly:      321.4449 deg
Mean motion:   12.06664240 rev/day
Decay rate:          4e-08 rev/day^2
Epoch rev:            6966
Semi major axis:  8026.683 km
Anom period:    119.337257 min
Apogee:           1670.344 km
Perigee:          1643.259 km
```

```
Satellite: rs-7
Catalog number: 13001
Epoch time:      83188.11835852
   Thu Jul  7 02:50:26 1983 UTC
Element set:          114
Inclination:       82.9571 deg
R of node:        329.0831 deg
Eccentricity:     0.0021917
Arg of perigee:     27.6065 deg
Mean anomaly:      332.6152 deg
Mean motion:   12.08673143 rev/day
Decay rate:          4e-08 rev/day^2
Epoch rev:            6846
Semi major axis:  8017.782 km
Anom period:    119.138909 min
Apogee:           1661.733 km
Perigee:          1626.588 km
```

```
Satellite: oscar-10
Catalog number: 14129
Epoch time:      83198.00000000
   Sun Jul 17 00:00:00 1983 UTC
Element set:           DC9
Inclination:       25.8731 deg
RA of node:       250.0137 deg
Eccentricity:     0.6043432
Arg of perigee:    187.3701 deg
Mean anomaly:      333.5787 deg
Mean motion:    2.05847913 rev/day
Decay rate:              0 rev/day^2
Epoch rev:               8
Semi major axis: 26106.227 km
Anom period:    699.545591 min
Apogee:          35505.270 km
Perigee:          3951.028 km
```

```
Satellite: rs-5
Catalog number: 12999
Epoch time:      83187.91491135
   Wed Jul  6 21:57:28 1983 UTC
Element set:          101
Inclination:       82.9464 deg
RA of node:       331.4017 deg
Eccentricity:     0.0011509
Arg of perigee:     93.5848 deg
Mean anomaly:      266.6495 deg
Mean motion:   12.05037892 rev/day
Decay rate:          4e-08 rev/day^2
Epoch rev:            6823
Semi major axis:  8033.909 km
Anom period:    119.498317 min
Apogee:           1685.991 km
Perigee:          1667.498 km
```

```
Satellite: rs-8
Catalog number: 12998
Epoch time:      83192.40137124
   Mon Jul 11 09:37:58 1983 UTC
Element set:          233
Inclination:       82.9579 deg
RA of node:       330.1663 deg
Eccentricity:     0.0019952
Arg of perigee:    129.6393 deg
Mean anomaly:      230.6419 deg
Mean motion:   12.02934730 rev/day
Decay rate:          4e-08 rev/day^2
Epoch rev:            6865
Semi major axis:  8043.276 km
Anom period:    119.707243 min
Apogee:           1693.670 km
Perigee:          1661.574 km
```

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